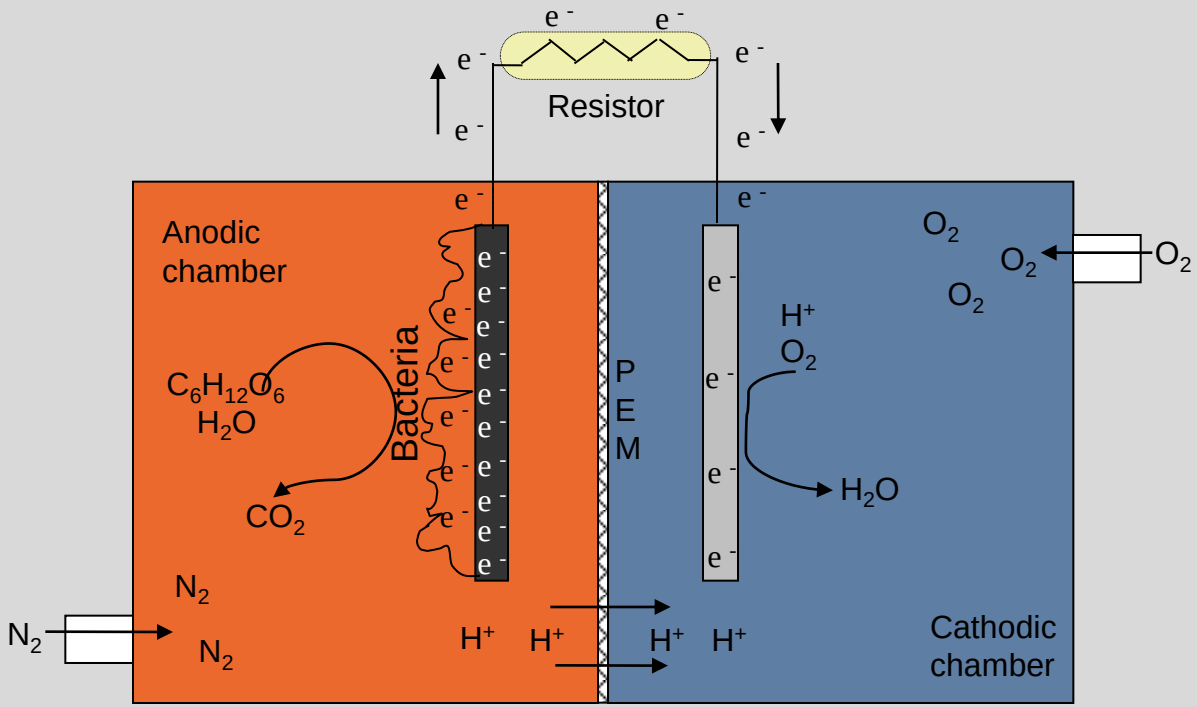
University of Minho
Dep. of Biological Engineering
Dep. of Chemistry

Development of a Compact Microbial Fuel Cell for Isolated Environments

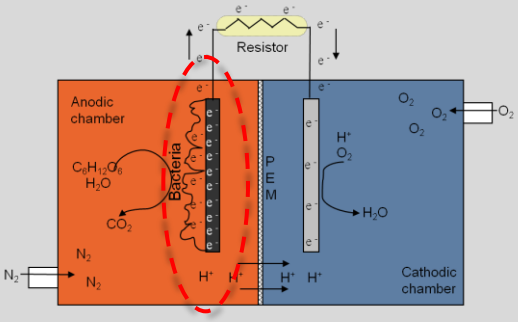
Luciana Peixoto, António G. Brito, Pier Parpot, Regina Nogueira

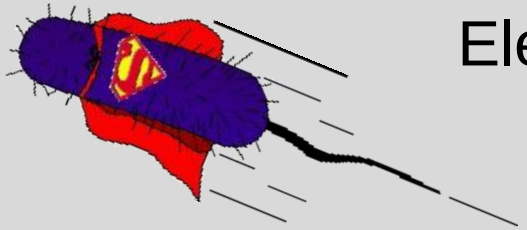
Microbial Fuel Cells



Conventional MFC consist of an electrochemical reactor with anodic and cathodic compartments separated by a proton exchange membrane. Anode and cathode are connected to each other using an external resistance.

Microbial Fuel Cells Bacteria



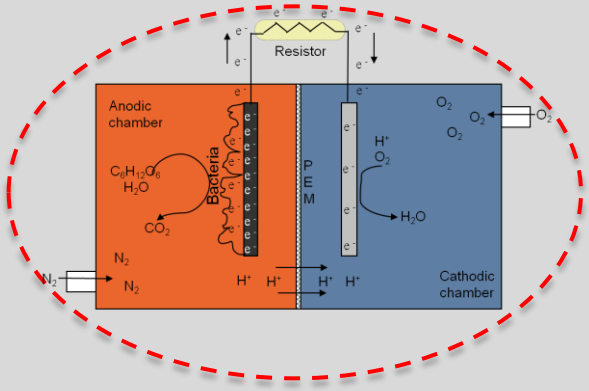


Electroactive bacteria

have the ability to transfer electrons directly to the anode electrode

- *Geobacter*
  - *G. sulfurreducens*
  - *G. metalirreducens*
- *Shewanella*
  - *S. oneidencis*
- *Actinobacteria*
- *Leptothrix*
- *Desulforomonas*

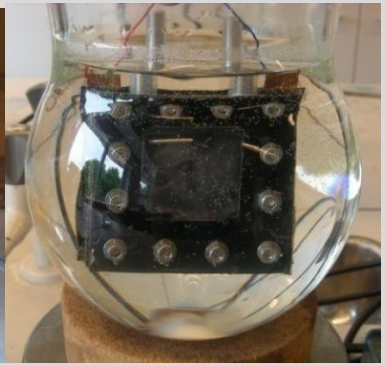
Microbial Fuel Cells configurations



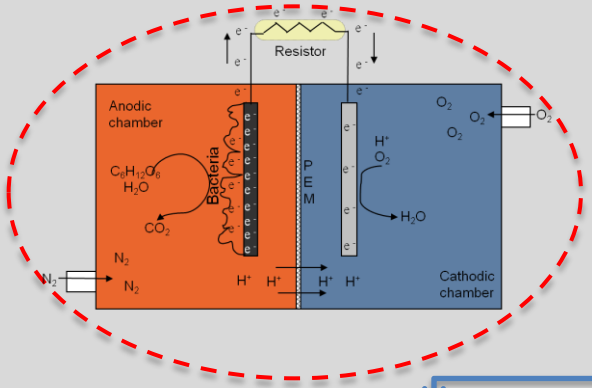
Two - chambers

Single - Chamber

Air-cathode



Microbial Fuel Cells applications

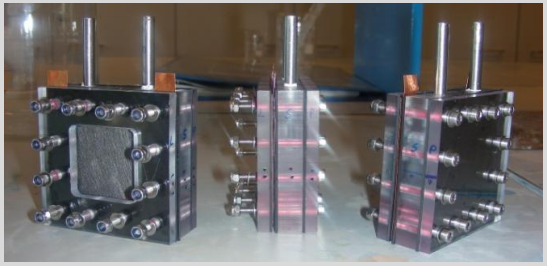


Several configurations permit different application

Compact MFC

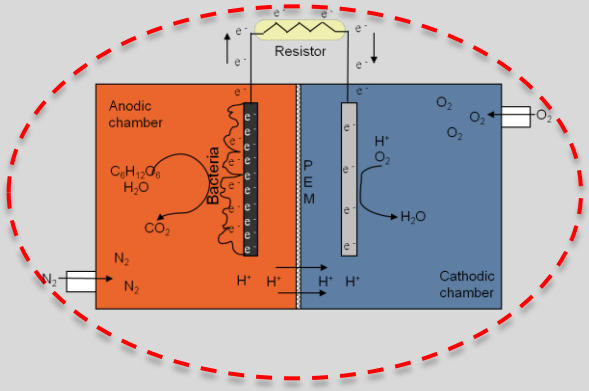
Isolated environments

- Lakes
- Rivers
- Deserts
- Mountains
- Space
- ….

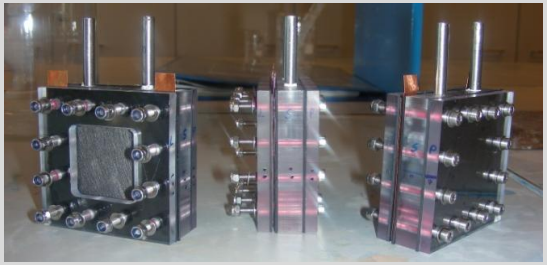


The main goal of our research is the development of compact Microbial Fuel Cells for several applications in isolated environments

Microbial Fuel Cells applications



Compact MFC → Isolated Environments

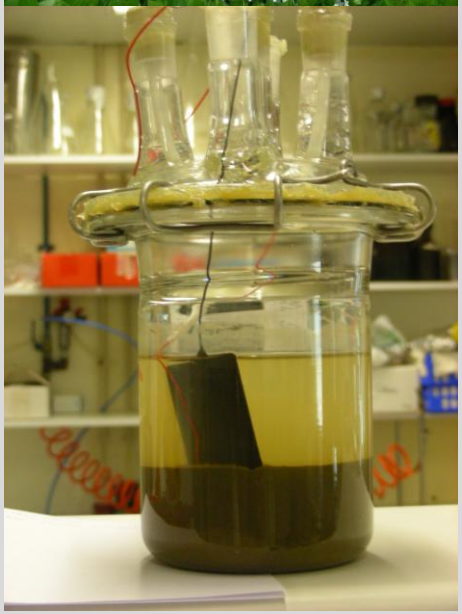


- Benthic MFC implementation in Volcanic Eutrophic lakes of Azores: monitorization and biorremediation

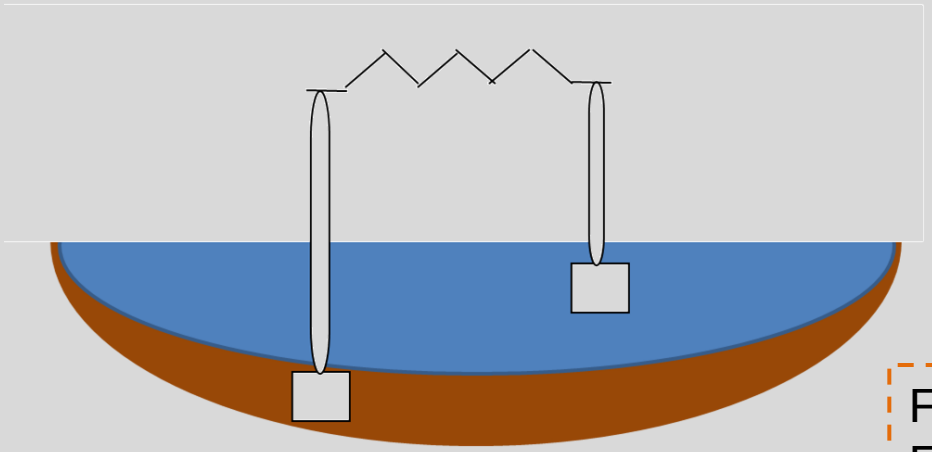
- Submersible microbial fuel cell-based biosensor for in situ BOD monitoring

- Optimization of operating conditions in Filter-Press FM01 as a compact MFC for electricity production on isolated environments

Towards Benthic Microbial Fuel Cell implementation in Volcanic Eutrophic lakes of Azores



A Benthic Microbial Fuel Cell (BMFC) consists of an MFC when an anode is embedded in anaerobic sediment and a cathode is suspended in the aerobic water column above the anode electrode



For Isolated Environments

Reference
Martins G., Peixoto L., Ribeiro D. C., Parpot P., Brito A. G., Nogueira R., (2010) "Towards Benthic Microbial Fuel Cell implementation in Volcanic Eutrophic lakes: bacterial electrochemical activity assessment in Lake Furnas (Azores) – Portugal", Bioelectrochemistry 78, 67–71

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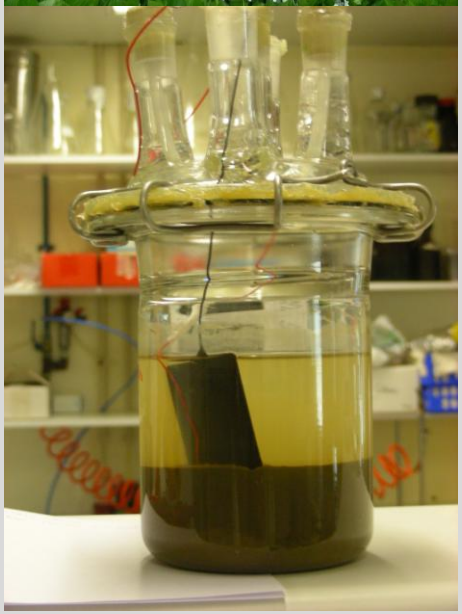
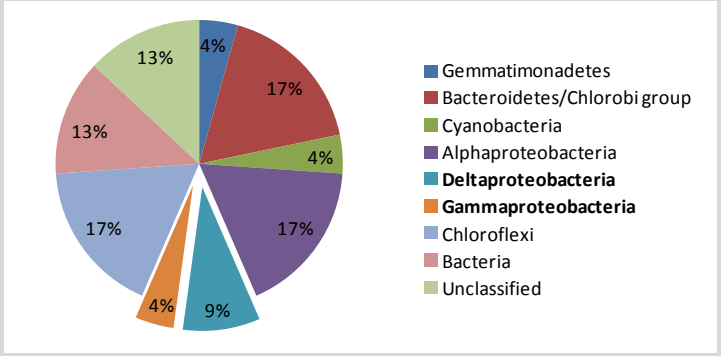


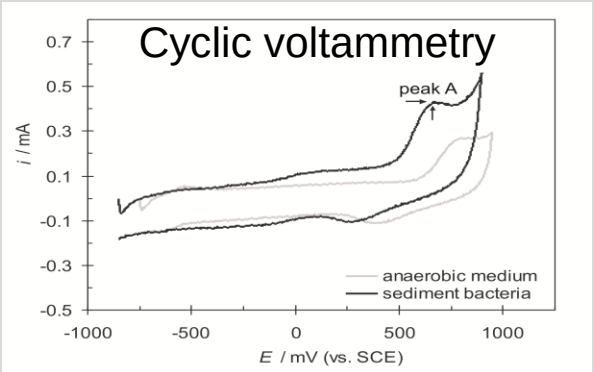
Production of electricity

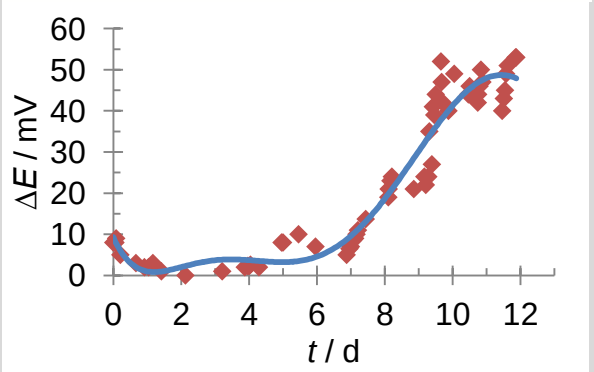
That can be used in sensors for monitorization

Lakes or water reservoirs

-Bacterial community
-Electroactivity of Bacteria
-BMFC implementation / power production







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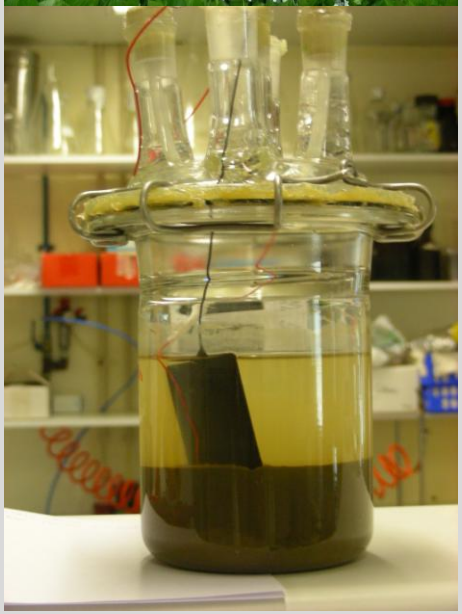
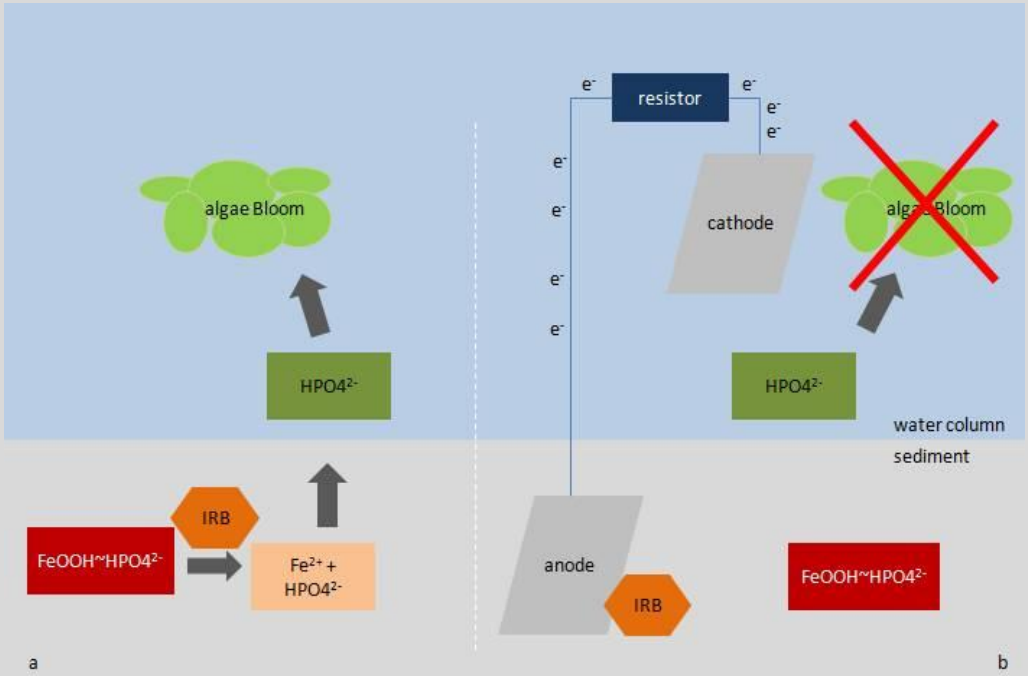


Bioremediation: Phosphorous control /
Removal of organic compounds



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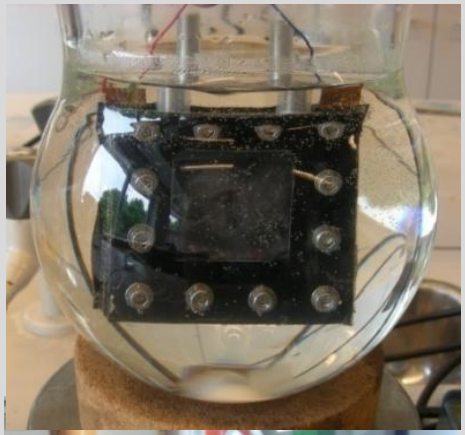
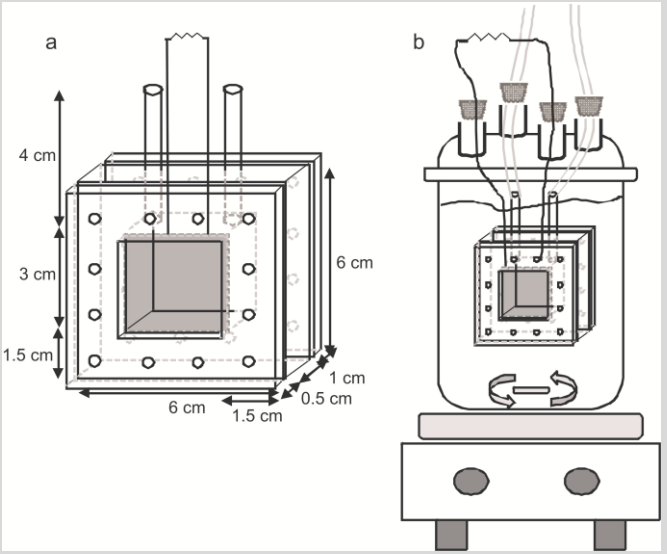
Submersible microbial fuel cell-based biosensor for in situ BOD monitoring



A SMFC is a novel configuration of MFC, it have an air-cathode chamber and an anode that are in direct contact with the solution of an anaerobic reactor.

The main difference from other MFC configurations is the absence of an anodic chamber

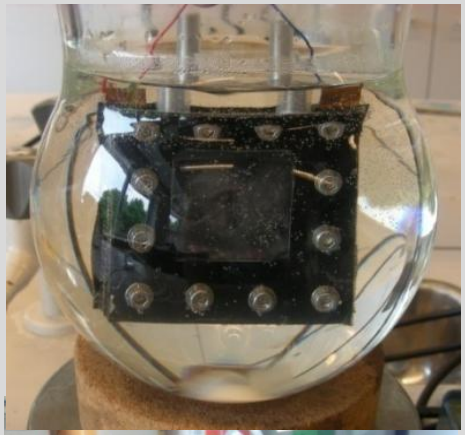
This configuration permits *in situ* measurements, and the answer time is smaller.



Very compact and portable MFC

Reference
Peixoto L., Min B., Martins G., Brito A.G., Kroff P., Parpot P., Angelidaki I., Nogueira R., (2011). "In situ microbial fuel cell-based biosensor for organic carbon", Bioelectrochemistry, 81, 99-103

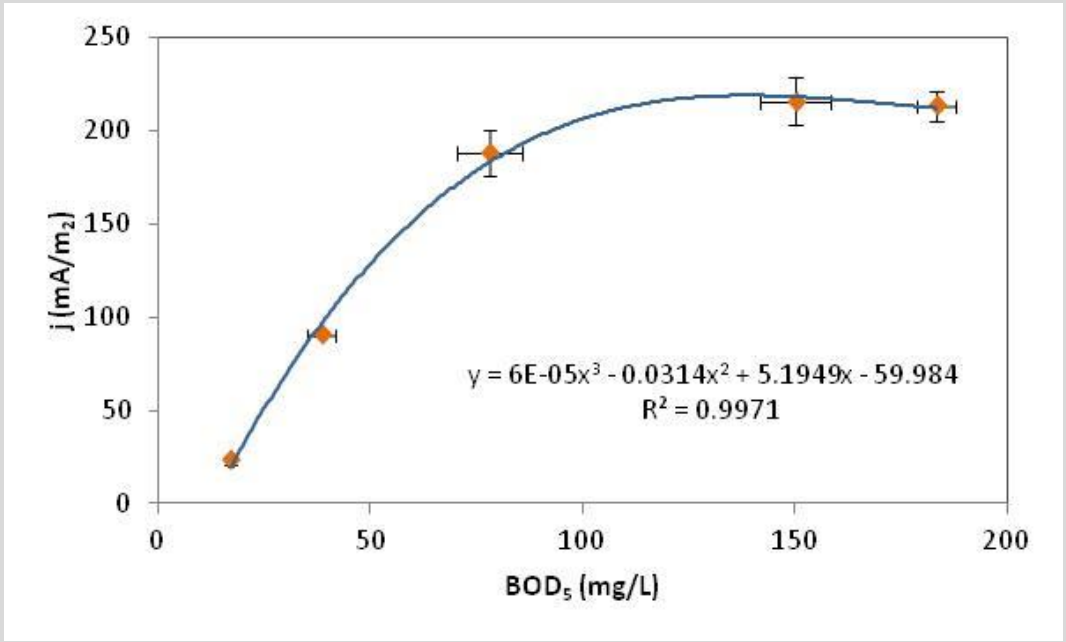
Submersible microbial fuel cell-based biosensor for in situ BOD monitoring



Electrical signal

The correlation between power generation and BOD

WW TP
Water reservoirs



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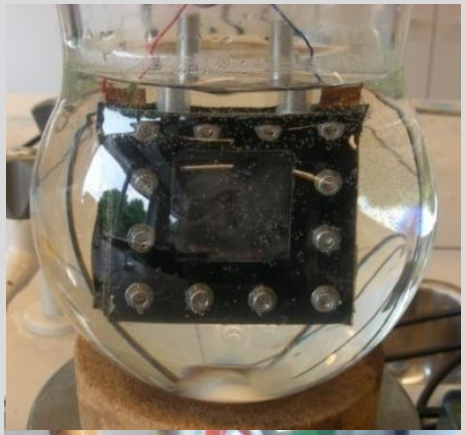
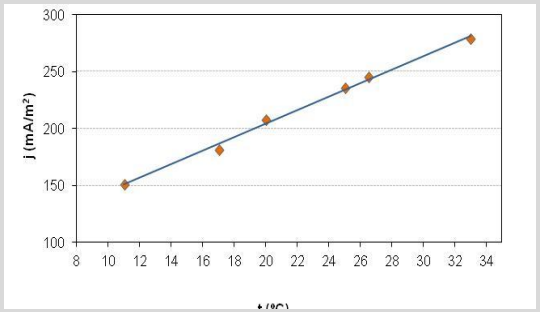


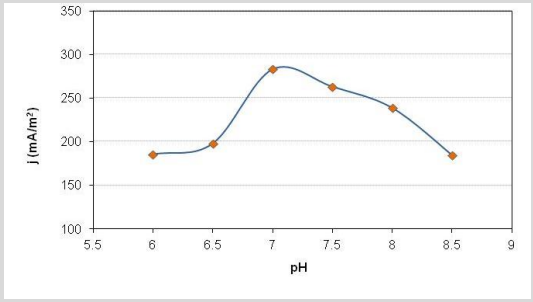
Effect of temperature , pH and, conductivity (σ) on current density

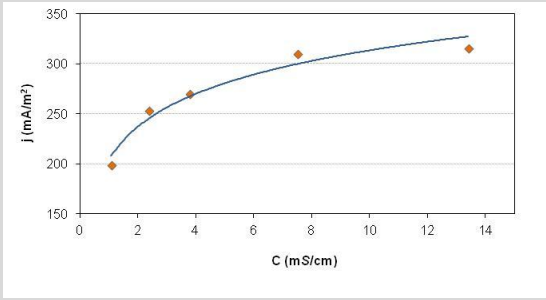
- j increased linearly with T, about 6 mA/(m² ºC)

-The maximum j was obtained at pH 7.0

- j increased with the σ, but the effect being more important between 1.1±0.012 and 2.1±0.013 mS/cm







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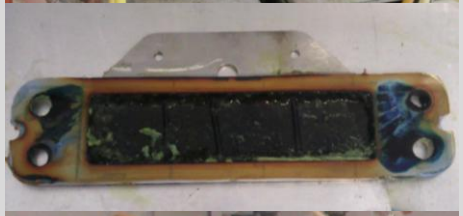
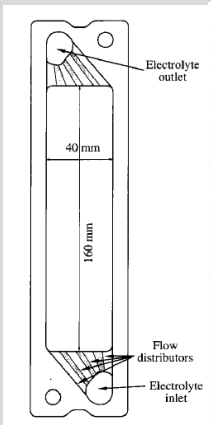
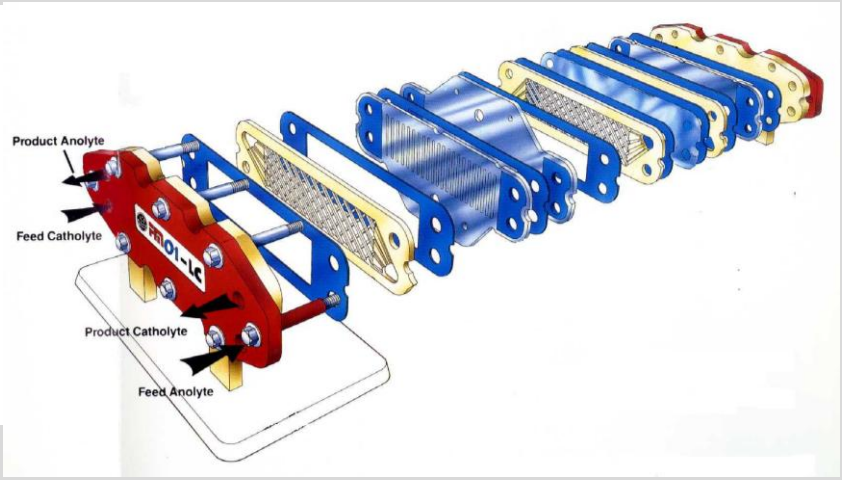
Optimization of operating conditions in Filter-Press FM01 as a compact MFC for isolated environments



A Filter-Press-Type FM01-LC (laboratory-scale commercial) is an electrochemical cell from ICI and was used as a two-chambers MFC





Resistor – 1 kΩ

Volume of the anode chamber – 1 mL

Separation of anode/cathode chambers – Nafion 117

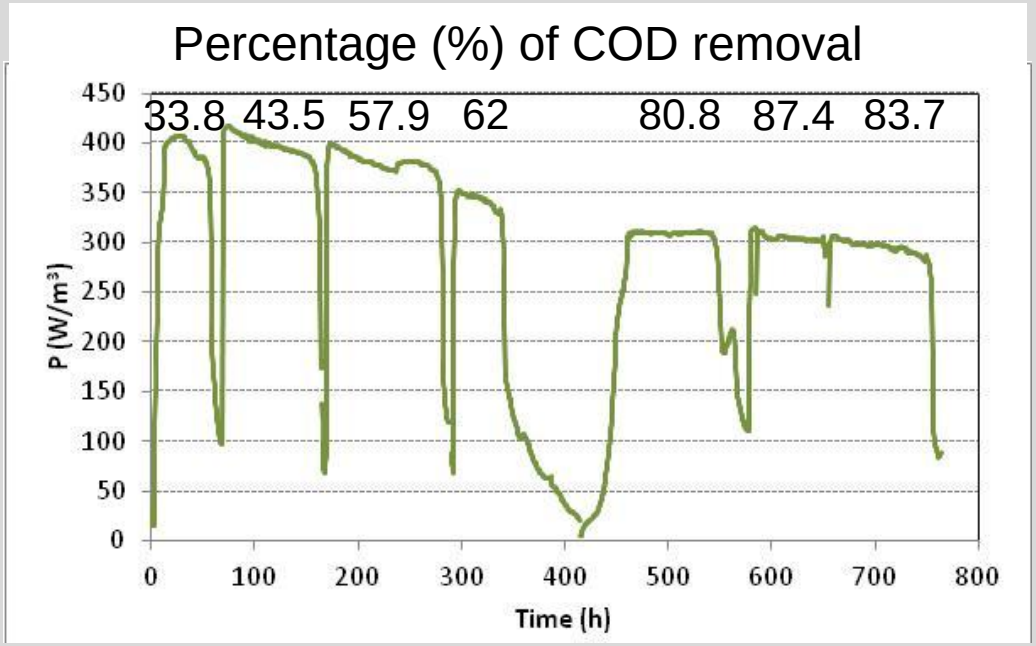
Electrodes – Carbon Toray with stainless steel supports
Electrode area – 64 cm^2

Optimization of operating conditions in Filter-Press FM01 as a compact MFC for isolated environments

Wastewater or another carbon source

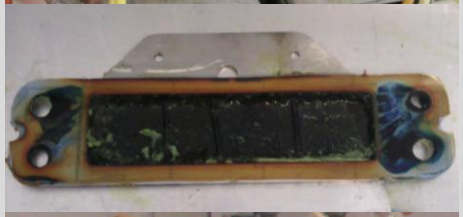
Production of Power density

Efficient carbon removal



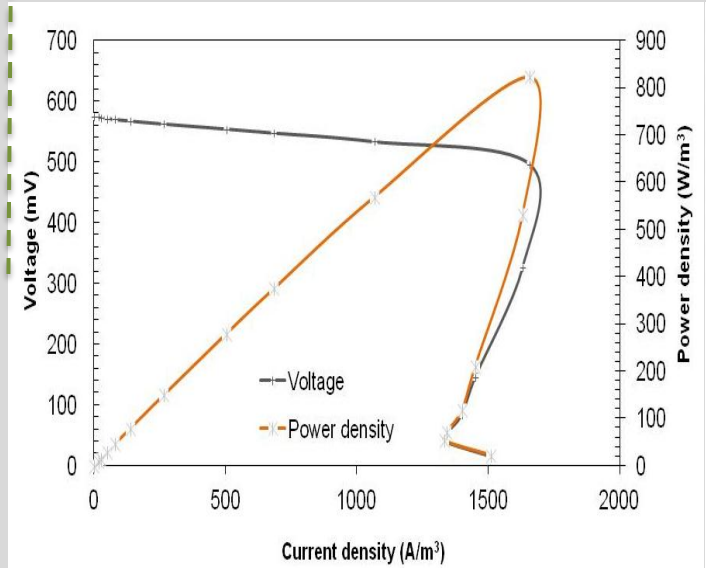
-After 2 cycles without power generation (data not showed), the power densities increased to reach the maximums of 400 W/m^3.
-Higher carbon removal in the region of the biofilm stability.

Optimization of operating conditions in Filter-Press FM01 as a compact MFC for isolated environments

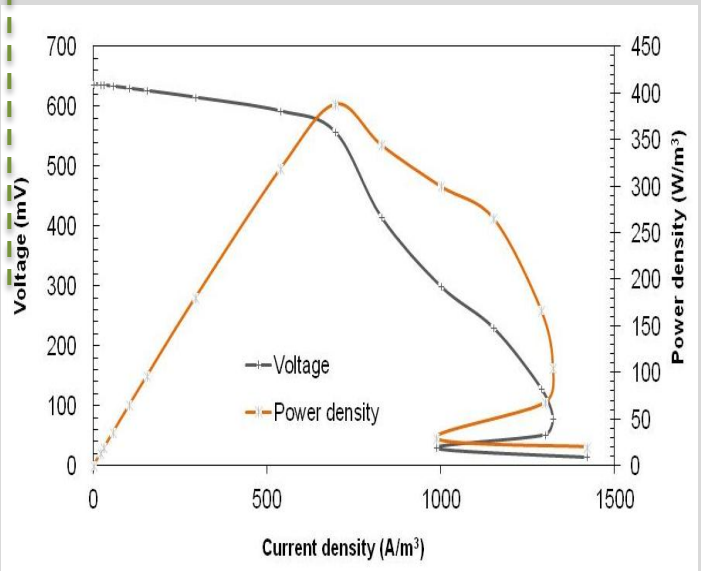


Polarization and Power curves

start



end



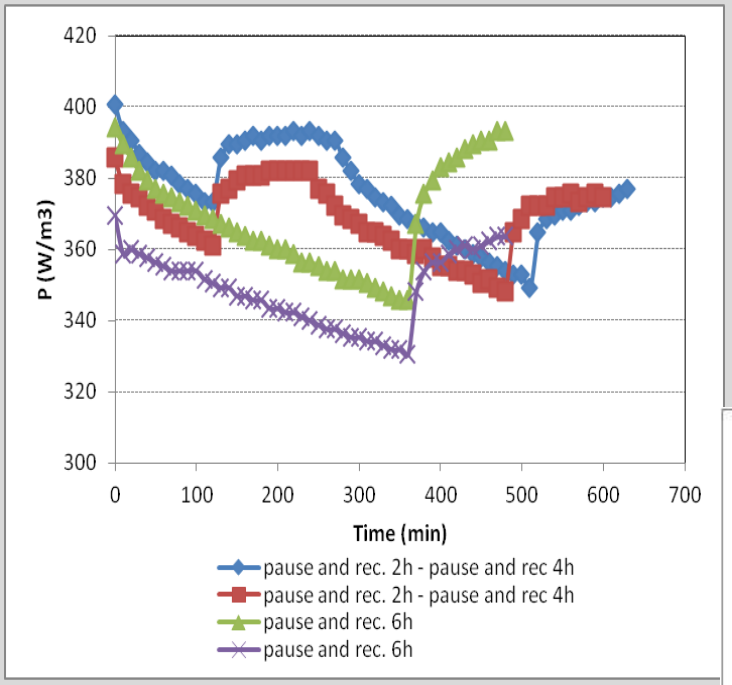
Maximum P with R: 300 Ω

R int: ≈ 0 Ω

Maximum P with R: 800 Ω

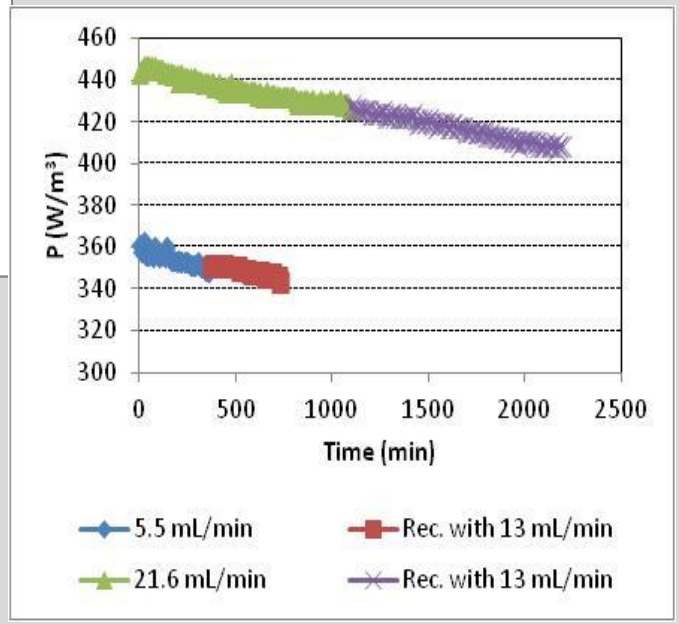
R int: ≈ 2 Ω

Optimization of operating conditions in Filter-Press FM01 as a compact MFC for isolated environments



- Influence of the influent flow on power generation

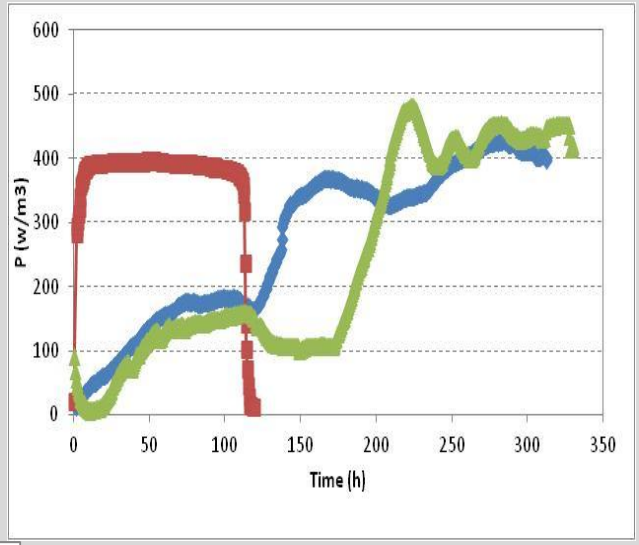
- Influence of feed interruptions on power generation

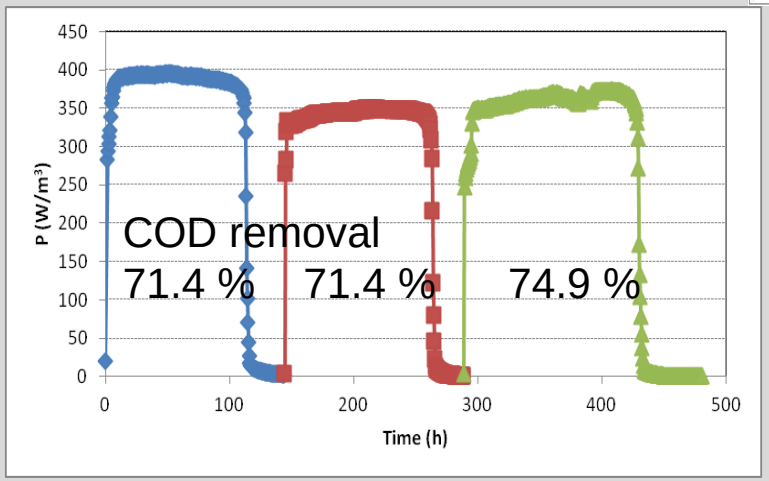


Optimization of operating conditions in Filter-Press FM01 as a compact MFC for isolated environments

- Influence of the N concentration and carbon removal

Wastewater diluted 1:50
COD load adjusted with Na-Acetate to 620 mg COD/L
Nitrate: ≈ 2.2 mg/L
Nitrite: ≈ 0.010 mg/L
Ammonium: ≈ 3 mg/L



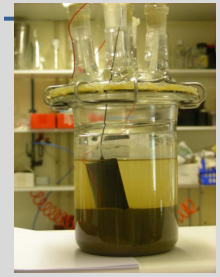


- Interference of the Fe-oxides as final electron acceptor

20 mM of Fe-citrate

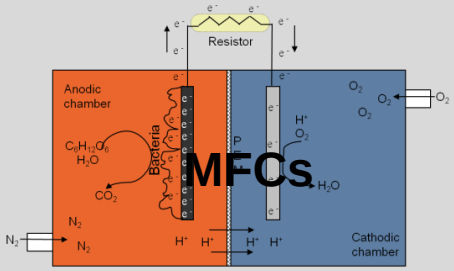
Conclusions

BMFC



SMFC

FM01



Simultaneous electricity production and carbon removal

Biosensors for monitorization

Energy for specific applications

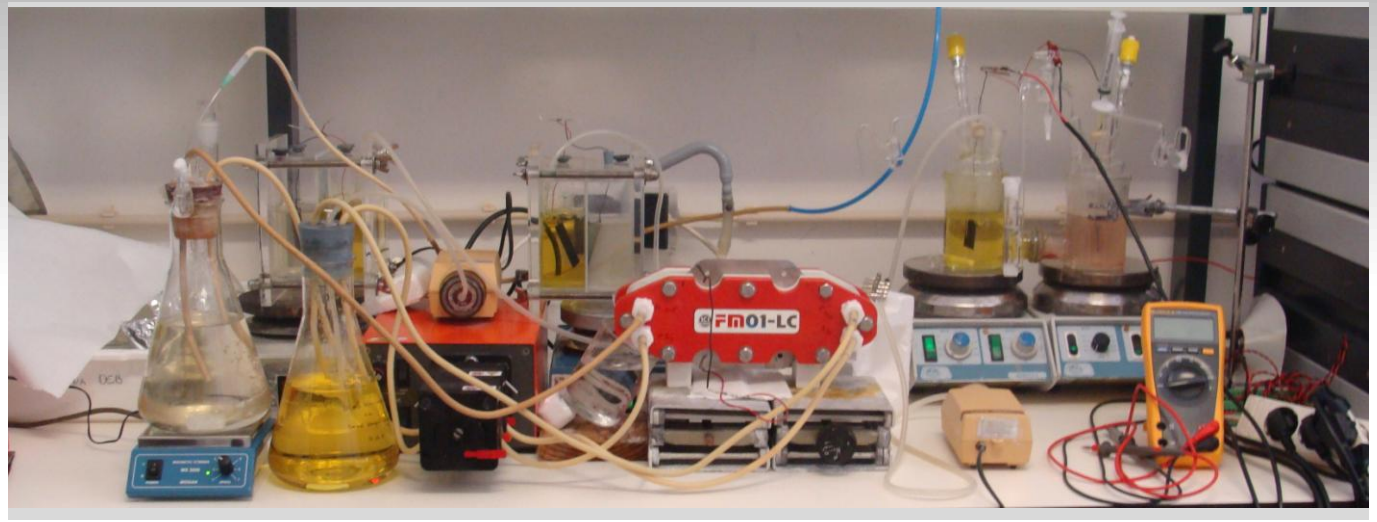
Isolated environments

Lakes
Rivers
Water reservoirs
WW TP
Waters with organic contents
Space
Deserts
Mountains
…

Acknoledgements

-Regina Nogueira, Pier Parpot and António Brito (Supervisors)
-Department of Biological Engineering and Department of Qhemistry from the University of Minho.
-Irini Angelidaki and Booki Min from the Department of Environmental Engineering -Technical University of Denmark.
-The Grant SFRH/BD/38331/2007 from Fundação para a Ciência e a Tecnologia (FCT)
- Financial assistance from Fundação Luso-Americana para o Desenvolvimento (FLAD)
-NASA, ESA and C3P

SFRH/BD/38331/2007



Thank you for your attention